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ABSTRACT

This paper set describes the implementation and evaluation efforts associated with the Richardson Independent School District's elementary science program which has been recognized as a Texas state exemplar in the National Association for Research in Science Teaching's (NSTA) 1985 Search for Excellence. Part I of the paper set outlines the network of activities that constitute the "Science Through Discovery" curriculum, including the nature of the administrative support and the inservice education. Part II and Part III of the paper set focus on the results of the evaluation components of the total implementation project. Student and teacher attitudes in experimental and control classes have been assessed over a two year period of time. In addition, student and teacher classroom behaviors were assessed in the same experimental and control classes during the second year of the project in order to ascertain the correlation between desired and actual implementation goals. The evaluation efforts associated with this project indicate that it is a most successful implementation. (Author)

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IMPLEMENTATION AND EVALUATION OF AN EXEMPLARY ELEMENTARY SCIENCE PROGRAM

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ABSTRACT

This paper set describes the implementation and evaluation efforts associated with the Richardson Independent School District's elementary science program which has been recognized as a Texas state exemplar in NSTA's 1985 Search for Excellence. Part I of the paper set outlines the network of activities that constitute the Science Through Discovery curriculum, including the nature of the administrative support and the inservice education. Part II and Part III of the paper set focus on the results of the evaluation components of the total implementation project. Student and teacher attitudes in experimental and control classes have been assessed over a two year period of time. In addition, student and teacher classroom behaviors were assessed in the same experimental and control classes during the second year of the project in order to ascertain the correlation between desired and actual implementation goals. The evaluation efforts associated with this project indicate that it is a most successful implementation.

I. A CONCEPTUAL FRAMEWORK FOR IMPLEMENTING AN EXEMPLARY ELEMENTARY SCIENCE CURRICULUM

BACKGROUND

During the 1982-83 academic year the Richardson Independent School District (RISD) conducted an internal audit to assess the status of science education. The audit was in anticipation of Texas Administrative Code Chapter 75 which requires an inquiry-oriented, process-approach to the teaching of science. In general, the audit revealed that the process-approach was not in wide usage by elementary teachers and that the science curriculum was not addressing the current goals in science education.

In response to the audit, and to national reports advocating a broadening of the science education curriculum, the district established a committee to implement, and evaluate their new K-6 Science Through Discovery curriculum. The Science Through Discovery curriculum emphasizes inquiry-oriented, process-approach science while addressing current goals in science education. Concomitant goals are to enhance teacher attitudes toward science and to broaden the science knowledge of teachers so that curriculum development efforts will be relevant. Within two years, the science program in Richardson has evolved from a program more closely resembling language arts to a program that was nominated as a Texas state exemplar in NSTA's 1985 Search for Excellence in Science Education.

IMPLEMENTATION PROCEDURES

The Science Through Discovery implementation will take five years. During the first year of implementation, 1983-84, SCIIS (Thier et al., 1978) was introduced into six of the 35 elementary schools in the district. SCIIS

was phased into eight additional schools during the 1984-85 academic year and the remaining 21 schools during 1985-86. Beginning in the third year (1985-86), and following a similar phase-in process, the SCIIS curriculum is being modified to emphasize the application of scientific concepts to students' daily lives with a focus on science, technology and societal issues in accordance with the science education goals for the 1980's and beyond. The curriculum development process focusing on the personal needs, societal issues, and career education awareness clusters (Harms and Yager, 1981) was initiated during a 1985 summer workshop. Those curricular materials are being implemented in the six schools that began the implementation project. Curriculum development will continue throughout the implementation process.

The major objective for 1983-84 was to assess the effectiveness of the program by comparing SCIIS student and teacher attitudes toward science to those of students and teachers in non-SCIIS classes. Results of that assessment have been reported by Kyle, Bonnstetter, McCloskey and Fults (1985). A longitudinal component to the attitudinal assessment was conducted during the 1984-85 academic year. Teacher and student classroom interactions were also assessed in order to ascertain the correlation between desired and actual implementation of the program. The evaluation efforts associated with this project support the fact that it is a most successful implementation. A good portion of this success must be attributed to the district-wide support associated with the project.

DISTRICT-WIDE SUPPORT: THE ESSENCE OF EXCELLENCE?

The district has funded extensive inservice education for teachers and principals, as well as provided administrative support and services.

Administrative support includes a Project Coordinator in addition to a K-12 Science Consultant. The coordinator assumes responsibility for centralized ordering of materials and supplies, inservice planning and operations, curriculum writing and management, budgeting, and problem solving for individual teachers. Local curriculum writing and continuous evaluation of the implementation process reflect efforts to establish and maintain the dynamic nature of the program. The district has funded a Living Materials Center to provide live organisms for classroom investigation; has established a related projects fund to purchase microscopes, other equipment, and related software; and, has correlated support services throughout the district with the new science scope and sequence. Thus, outdoor investigations at the Environmental Studies Center, inquiry lessons at the Planetarium, and audio-visual materials and books in the Television and Media Center and building libraries are all integral components of the Science Through Discovery curriculum. Finally, a sixth grade science specialist has been identified in each building to assist with the total implementation.

The most important component of the process is the inservice education that teachers and principals receive. The overall goal of the inservice education is to provide everyone associated with the curriculum with an understanding of: the nature of inquiry-oriented, process-approach science; and, the current goals in science education. There are five primary components to the inservice provided teachers and principals who are new to the implementation process:

1. A spring orientation introduces principals to the new science program, the philosophy and instructional strategies associated with process-approach science, as well as their responsibilities as an instructional leader. Administrators already engaged with the implementation process are present to answer questions and to support the importance of the project to the district.

2. In early August, teachers receive two days of in-service education. Teachers view slides and video-tapes regarding the program and the administrative support they can expect to receive. They also attend grade level sessions led by master teachers where they experience each physical science lesson that they will teach in the fall semester. These workshops also focus on key instructional concerns such as: teaching without a textbook; using outside resources in the class-room; evaluating and assessing student performance classroom management; and, the use and care of equip-ment and organisms in the science classroom. During the August meetings, building principals attend additional program evaluation sessions and are encouraged to attend various grade level sessions.

3. In October, grade level representatives from each building attend grade level meetings to discuss im-plementation progress and concerns. Teachers with prior program experience are present to answer questions; provide guidance, reassurance, and ideas; and to broaden the perspective of beginning teachers regarding the teaching of process-approach science.

4. Prior to the second semester, a one-day inservice workshop is provided for all new teachers focusing on the life science component of the curriculum.

5. Finally, a graduate course, or equivalent, is offered during the summer to provide teachers with science content and instructional strategy updating, as well as affording teachers the opportunity to develop curricular materials identified as essential components of the total Science Through Discovery scope and sequence.

Over 10% of all elementary teachers in the district attended the 1985 summer workshop entitled Elementary Science Curriculum Development. Curriculum development will continue in a 1986 summer workshop. Subsequent supplementation of the Science Through Discovery curriculum will be a continual process in order to ensure a dynamic, rather than static, elementary science program.

II. A LONGITUDINAL ASSESSMENT OF STUDENTS' AND TEACHERS' ATTITUDES TOWARD SCIENCE IN PROCESS-APPROACH VS. TRADITIONAL SCIENCE CLASSES

This two year longitudinal study was designed to assess the attitudes toward science of students and teachers in first- and second-year SCIIS classes compared to students and teachers in non-SCIIS classes. This study also identifies specific needs that teachers have regarding the teaching inquiry-oriented, process-approach science. The results of this survey provide valuable implementation information. In accordance with the Concerns-Based Adoption Model (Hall et al., 1975), it is imperative for teachers to accept and establish a routine pattern of use for an initial curricular innovation prior to initiating any changes in the use of the innovation or exploring modifications to the innovation. Thus, phase one of the implementation program must be established successfully (i.e., implementing SCIIS) prior to integrating the supplemental curricular materials as discussed in the preceeding paper.

Four questions provide a focus for the results presented:

1. How do the attitudes toward science of students in first-year SCIIS classes compare to students in non-SCIIS classes (1984-1985 data)?

2. How do the attitudes toward science of first-year SCIIS students in 1984-85 compare to their responses as non-SCIIS students during 1983-84? That is, does the nature of the curriculum enhance students' attitudes toward science?

3. How do the attitudes toward science of second-year SCIIS students in 1984-85 compare to their responses as first-year SCIIS students during 1983-84? That is, are the positive attitudes toward science that were assessed in 1983-84 maintained; or, were the 1983-84 data merely reflecting students' reactions to the results of the curriculum changes (a Hawthorne effect)?

4. How do the attitudes toward science of teachers who have received inservice education and who have SCIIS experience compare to teachers who have neither received inservice education nor taught SCIIS?

Of the 117 teacher questionnaires distributed in 1983-84, 92.3% were returned. The 1984-85 survey reflects an 87.3% return response. Due to the exceptionally high response to the initial survey, there was no attempt to contact non-respondents. The 1983-84 student sample was comprised of 228 SCIIS students (54% male and 46% female) and 228 non-SCIIS students (52% male and 48% female). The 1984-85 student sample is comprised of 230 first-year SCIIS students (51% male and 49% female); 226 second-year SCIIS students (54% male and 46% female); and 219 non-SCIIS students (49% male and 51% female). All of the student questionnaires were completed according to the directions provided.

RESULTS AND IMPLICATIONS

The results of the attitudinal assessment substantiate the fact that students have a preference for inquiry-oriented, process-approach science. Table I shows that over 50% of the first-year SCIIS students in 1984-85 chose science as their first or second favorite subject in school. Only 16.9% of the current year non-SCIIS students indicate similar preferences. The longitudinal aspect of this study further substantiates such student preferences. While 50.5% of first-year SCIIS students chose science as their first or second favorite subject, only 20.6% of those students made similar claims the preceding year while in non-SCIIS classes. Furthermore, the data for first-year SCIIS students progressing to the second year of SCIIS remain stable (43.4% to 44.8%). It seems clear that first-year SCIIS students are not responding to the results of a curricular innovation; rather, they are exhibiting a clear preference for the nature of the curriculum.

This dichotomy is further dramatized by the fact that only 7.8% of the current year first-year SCIIS students chose science as their least favorite subject compared to 18.3% of their counterparts in non-SCIIS classes. From a longitudinal perspective, moving from a traditional setting to a process-approach class resulted in 11% of the first-year SCIIS students changing their least favorite subject from science to another discipline. Even more surprising is the fact that as students progressed from first-year SCIIS classes to second-year SCIIS classes the percentage of students indicating that science was their least favorite subject declined from 7% to 3%.

The data reported in this longitudinal study verify that student involvement in SCIIS classes in Richardson results in:

1. students being more likely to choose science as either their first or second favorite subject in school. Similarly, students are less likely to choose science as their least favorite subject in school.
2. students wishing that they had more time for science.
3. students desiring more "kinds" of science offerings.
4. students preferring scientific investigation with "living things."
5. students realizing that their science teacher values a high frequency of questions.
6. students realizing that their science teacher values their questions; and, that questioning is important in science.
7. students realizing that school science is interesting, exciting, and fun.
8. students realizing that through their inquiries they develop a feeling of successfulness.

The teacher survey reveals that the entering behaviors and perceptions of SCIIS and non-SCIIS teachers are very similar. Approximately two-thirds of all teachers sampled indicated that Language Arts was either their first

or second favorite subject while they were in school (K-12). While over 50% of first-year SCIIS students chose science as their first or second favorite subject in school, only 12% of all teachers indicated similar preferences for science. Concomitantly, over 20% of all teachers sampled indicated that science was their least favorite subject, followed only by mathematics (22%). In effect then, the academic subjects which students find most interesting and exciting were least favored by their teachers.

Teachers presently associated with the SCIIS program, however, exhibit many of the characteristics found among teachers in exemplary science programs (Bonnstetter and Yager, 1985). From our teacher survey we found that SCIIS teachers:

1. feel more qualified to teach science. Second year SCIIS teachers have more positive attitudes toward science; possess a better understanding of the nature of science; and, are more likely to state that they understand science and like teaching science.

2. have far fewer needs for assistance.

3. are less likely to view students as uninterested in science.

4. are less likely to need or use films, filmstrips, tapes, the overhead projector, or closed circuit TV.

5. provide hands-on science material at least once a week, if not daily, and regularly use living plants and animals in their teaching.

6. are less likely to lecture on a daily or weekly basis; more likely to have discussions in class; and use numerous teacher demonstrations.

7. view principles, local inservices, local subject specialists, publishers, and other teachers as important sources of curriculum information.

8. consider involvement in project development an important means of receiving information about curriculum.

9. spend less time working with the entire class as a group and spend more time working with small groups and supervising individual student activities.

10. spend more time teaching science than they did 3 years ago, and prefer the SCIIS program to science textbooks or programs used previously.

It is interesting to note that almost all teachers believe that their science classes are exciting, while a slightly higher percentage of SCIIS teachers maintain that they make studying science fun, exciting and interesting. SCIIS students agree with their teachers' perceptions, non-SCIIS students disagree with their teachers' perceptions. Finally, approximately 60% of all teachers claim that they like teaching science. In spite of their preference for teaching or not teaching science, only 25% of the teachers surveyed feel as though they know alot about science. Not surprisingly, about the same percentage of teachers feel adequately prepared to teach science. Over one-third of the teachers sampled indicated a need for future preparation with regard to the content and concepts in science and "how" to teach science. Another 25% feel that they need more preparation regarding the content and concepts taught in their science classes. Regardless of how successful the SCIIS implementation process appears from viewing the student data, it is clear that teachers have concerns about science and how to teach science. With almost two-thirds of SCIIS and non-SCIIS teachers expressing such concerns, it would appear as though future inservicing is necessary in order to ensure longevity for the science curriculum innovations. The data reported in this study however, suggest that the nature of process-approach science does allow teachers to present a much more positive and exciting image of science.

III. AN ANALYSIS OF STUDENT AND TEACHER BEHAVIORS IN PROCESS-APPROACH VS. TRADITIONAL ELEMENTARY SCIENCE CLASSES

This study was designed to assess specific student and teacher behaviors in first- and second-year SCIIS classes compared to students and teachers in non-SCIIS classes. Two questions provide a focus for the results presented in this study:

1. Do the mean interaction frequencies for the learning mode, activity context and specific student behaviors differ among students in SCIIS classes compared to students in non-SCIIS classes?
2. Do the mean interaction frequencies for the teaching mode, activity context and specific teacher behaviors differ among teachers in SCIIS classes compared to teachers in non-SCIIS classes?

This study, in conjunction with the previous paper in this paper set, provides valuable information regarding the nature of inquiry-oriented, process-approach science classes, as well as identifies specific needs that teachers have regarding the teaching of inquiry-oriented, process-approach science.

PROCEDURES

This study involved two component parts: the development of an interaction analysis system to objectively and systematically assess teacher and student behaviors in elementary science classes; and, the subsequent coding and analysis of 69 full-period science classes.

The teacher sample consisted of thirty-four teachers selected randomly to participate in this study (two first-year SCIIS and non-

SCIIS teachers at each grade level, 1-6; and, two second-year SCIIS teachers in grades 2-6). Two classroom observers observed two entire science classes taught by each teacher selected between March 24 and May 25, 1985. The observers used Datamyte data collectors to record the specific behaviors identified by the Science Interaction Category Systems. The teachers' behaviors were coded for the entire science class. During the 68 classroom observations, 199 students were selected randomly and their behaviors were coded for approximately 10 minutes per observation. The student sample is comprised of 71 non-SCIIS students (51% male and 49% female), 68 first-year SCIIS students (56% male and 44% female), and 60 second-year SCIIS students (50% male and female).

Three dimensions of the classroom interactions were coded: 1) the teaching/learning mode, 2) the activity context within the teaching/learning mode, and 3) the specific behavior exhibited by the teacher or student. Intercoder reliability using the Scott coefficient was .87 for teacher observations and .91 for student observations.

RESULTS AND IMPLICATIONS

The results of the classroom observations (see Table II) substantiate the fact that students in SCIIS classes are more actively engaged with the scientific process than are students in non-SCIIS classes. Students in first-year SCIIS classes are engaged with manipulatives 82% of the total class time, while second-year SCIIS students spend 72% of their available science time engaged with manipulatives. These results are quite favorable when compared to non-SCIIS students who only spend 32% of their science class time engaged with manipulatives. Further, non-SCIIS students spend over 50% of their allocated science time engaged in large group settings without manipulatives.

The SCIIS student data also dispels a common sexual stereotype. It is generally believed that females in inquiry-oriented science classes are more passive than males and less actively engaged with the processes associated with inquiry. The data reveal that female students spend a greater percentage of the total class time engaged with manipulatives.

SCIIS teachers are engaged instructionally with manipulatives about half of the total class time, whereas non-SCIIS teachers only work with manipulatives 16% of the time (see Table III). It is also interesting to note that while non-SCIIS teachers spend far less instructional time engaged with manipulatives that a greater percentage of their time is devoted to administrative and/or procedural tasks.

It is clear that the nature of process-approach science classes positively affects the interactive structure of science classes. However, when the specific teacher and student behaviors are analyzed, there are few observable behavioral differences between teachers or students in SCIIS classes compared to non-SCIIS classes. These results would apparently confirm the self-reported need of teachers regarding assistance related to implementing effective instructional strategies for process-approach science. For example, regardless of the interactive nature or structure of the science class:

1. there are no observable differences in the frequency of initiating or responding behaviors for either students or teachers. Students initiate interaction less than 5% of the time. Further, students ask unsolicited questions directed toward either the teacher or other students less than 2% of the time. Teachers seldom, if ever, initiate interactions with students in an independent, out of the instructional mode context.

2. over 90% of the questions that teachers ask are factual recall questions. Further, teacher seldom (less than 1% of the time) initiate interaction with students by asking questions -- even in inquiry-oriented classes.

Thus, in addition to implementing a new and different curriculum, teachers must begin to implement the instructional strategies associated with the curriculum. Teachers must model the importance of initiating interactions and asking extended thought questions. Such behavioral interventions are essential in order to ensure that process-approach science classes promote the desired acquisition of higher level cognitive skills advocated by Harms and Yager (1981) and the National Science Board Commission (1983).

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TABLE I

STUDENT PERCEPTIONS OF THEIR SCIENCE CLASS*

	1983-84		1984-85		1983-84
	Non-SCIIS (N = 228)	SCIIS (N = 230)	Non-SCIIS (N = 219)	2nd yr SCIIS (N = 226)	SCIIS (N = 228)
Science is My:					
First or second favorite subject in school	21	51	17	45	43
Least favorite subject in school	18	8	18	3	7
Science is:					
Fun	53	76	52	82	85
Interesting	65	78	68	83	88
Exciting	44	62	39	73	70
Boring	35	22	40	17	13
Science makes me feel:					
Uncomfortable	24	14	18	16	11
Successful	45	55	36	56	59
Curious	56	69	54	74	76

*Reported in percentage of students responding positively to similarly phrased items on a 40 item attitudinal survey; percentages are rounded to the nearest whole number.

TABLE II

PROFILE OF STUDENT LEARNING MODE
IN PERCENTAGE OF CLASS TIME ACROSS ALL GRADES*

Learning Mode	Non-SCIIS			1st Yr. SCIIS			2nd Yr. SCIIS		
	All Ss	M	F	All Ss	M	F	All Ss	M	F
Engaged With Manipulatives:									
Independent Work	4	4	4	9	3	14	10	11	8
Small Group Work (2-5 Ss)	4	3	4	28	30	26	28	19	40
Large Group Work (> 6 Ss)	24	25	23	45	41	52	34	31	37
Not Engaged With Manipulatives:									
Independent Work	16	16	16	1	2	1	1	3	1
Small Group Work (2-5 Ss)	1	0	2	1	1	0	1	0	1
Large Group Work (> 6 Ss)	52	52	51	16	24	7	26	36	13
Total Work W/Manipulatives	32	32	31	82	74	92	72	61	85
Total Work W/Out Manipulatives	69	68	69	18	27	8	28	39	15

*Due to rounding error, percentages may not total to 100%

TABLE III

PROFILE OF TEACHER INSTRUCTIONAL MODE
IN PERCENTAGE OF CLASS TIME ACROSS ALL GRADES*

Instructional Mode	Non-SCIIS	1st Yr. SCIIS	2nd Yr. SCIIS
Engaged With Manipulatives:			
Independent Work	3	4	2
Small Group Work (2-5 Ss)	1	10	7
Large Group Work (> 6 Ss)	12	31	45
Not Engaged With Manipulatives:			
Independent Work	7	2	4
Small Group Work (2-5 Ss)	3	3	1
Large Group Work (> 6 Ss)	74	50	40
Total Instruction W/Manipulatives	16	45	54
Total Instruction W/Out Manipulatives	84	55	45
%age of Total Time Devoted To Administrative/procedural Tasks	29	24	20

*Due to rounding error, percentages may not total to 100%